

THE GENERIC COMPACT AUTOMATIC TEST EQUIPMENT(GCATE) BASED ON SERIAL COMMUNICATION FOR FIGHTER AIRCRAFTS

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ABSTRACT

Different Test Equipment (TE) required for the testing of serial communication based avionics systems for different aircrafts are usually supplied by the corresponding manufacturer. So procurement and maintenance of different TEs for the different avionics systems is not effective in terms of cost and operation. Additionally, the cost and time overheads that arise to carry out any changes in the Test equipment, with evolving hardware and software requirements of a particular avionics system like a black box over the years and has to be considered. Hence, it is necessary to have a Generic& Compact type of ATE to address various testing needs of Avionics system and also assurance for the future evolution of an avionics system like a black box. As in today's scenario increase in usage of digital systems and standardization of data buses in avionics, the need for Generic Compact Automatic Test Equipment(GCATE) to test a variety of systems and subsystems arises. These GCATEs are built to support various testing needs of avionics systems and may require functioning during the entire lifecycle of aircraft project, which is minimum 25 years. To cater for hardware modification, obsolescence management and design up gradations of both GCATE and avionics system for such a long time span; the need for robust and maintainable Application software which is hosted within GCATE arises. A software engineering team may spend months of effort building software to an obsolete specification or design up gradations. It has mainly the following features:

- *Open system architecture method resulting in significant cost and time saving*
- *Creative design capable of meeting the testing requirement of various avionics systems Reconfigurable design concept and modular design approach to make it compactable for other platform*
- *Modular, Reusable and Non editable software*
- *Automatic test methodology and non editable report generation*
- *In-house developed compact and cost effective solution*

This paper describes mainly the functional capabilities features, system-level design of GCATE. It also presents the innovative aspects, cost effectiveness and financial impact of the solution. Finally, it highlights the key lessons learned during the development, testing and certification process.

KEYWORDS:

Line Replaceable Unit (LRU), Test Rig, Avionics System, Test Equipment, Cost Effectiveness, Innovation & Generic Compact Automatic Test Equipment

Received: Nov 12, 2018; **Accepted:** Dec 02, 2018; **Published:** Jan 23, 2019; **Paper Id.:** IJMPERDFEB201946

1. INTRODUCTION

Avionics System undergoes extensive testing on test equipment/rigs and in-flight to meet the requirement of certifications, during aircraft/avionics system development phase. The Test Equipment used in the avionics system development phase, involves the following level of functional testing:

- Software Integration
- System Integration
- Acceptance Testing
- Aircraft Pre-Installation Checks
- Snag Verification and rectification

One of the major challenges is to develop an Avionics test system to balance the life cycle mismatch of test equipment that's commonly deployed for 30+ years with the shorter life cycle of commercial-off the shelf components often used in those systems. To ensure long term supportability of these systems, it is important to plan for obsolescence issues starting in the product development phase and continuing through the sustaining state to end of life. Successful long term support of test systems requires careful up-front planning, proper system architecture, and a comprehensive long term life management plan.

The GCATE is designed for testing the serviceability of avionics LRUs that too serial communication based. The serial communication based LRUs can be tested in both standalone and integration mode on this rig. The GCATE has been conceptualized in lines of testing philosophy of reading the health status to ascertain the system integrity. The rig has capability to simulate and monitor the parameters to be recorded. This will also support future software update for the production aircraft. This can be used for production line pre-installation (PI) check, system integration check in an optimized way. The GCATE supports the testing required at the aircraft production house or Service base. It is capable of detecting a detailed internal module failure, fault logging, and assisting further rectification. The GCATE is also developed to incorporate the features of the Test Equipment that has been used at the development phase of the aircraft in order to meet the testing requirement and upgrade.

2. GENERAL FEATURES OF GROUND EQUIPMENTS

Following section shows the general features of ground equipment to be used at various stages of:

2.1 Development Base

- ATE must be capable of carrying out detailed testing of the Line replaceable unit (LRU),
- Hardware in loop testing of LRU (Line replaceable unit),
- Testing in Standalone as well as in Integration mode with other LRU,
- Application software uploading to LRU (Line replaceable unit).
- Support in Aircraft level Integration and Aircraft level checks

2.2 Production Base

- Serviceability check of LRU(Line replaceable unit)
- Support in Aircraft level Integration and Aircraft level checks

2.3 Customer Base

- Support in Serviceability check of LRU (Line replaceable unit)
- Support in Aircraft level Integration and Aircraft level checks

GCATE is designed to meet these general features of Ground Test Equipment along with various other features as detailed in this paper.

3. DISCRIPTION OF GCATE

3.1 Test Rig- Salient Features

The salient features of the test rig are as given below:

- Serviceability checks of 10 different types of Black Boxes in a small space of 60×40×45cm
- Supports both standalone and system integration mode checks.
- Black Box Programming Facility, for easy loading of the software for the production Line.
- Auto test to reducing the man-power& time requirement for the operation of the test rig.
- Innovative LRU front loading mechanism hence auto test to reducing the man power requirement for the operation of test rig.
- Open System Architecture USB back plane based compact methodology, saving design and development costs and reducing design cycle time. Modular hardware architecture with pluggable hardware (input/output) modules, providing easy addition or deletion of hardware functionality.
- In-house developed Compact and cost effective Solution.
- Modular Generic open system Software Architecture with pluggable software module, providing easy addition or deletion of software functionality.
- Software can be easily upgraded for future test rigs.
- Applicable to different platforms, with configurable hardware and software.
- Easy maintainable and upgradable in reference to calibration with LRU ICD (interface control document).
- Data Visualization using numeric display and offline data analysis.
- Flight data visualization in real time.
- Flight profile recreation and stimulation using flight data.
- Rugged and Portable hardware for testing of avionics system on modern aircraft.

- Generic RS232, RS422, RS485, MIL 1553, ARINC-717 & ARINC429 interfaces for the data acquisition, data loading, downloading and LRU programming.
- Scope for future enhancement due the modular Hardware & Software design.

Break in & Break out capability for all signals that interface with the rig. This break in/out capability allows the following:

- Signal Monitoring
- Signal Isolation
- Signal Injection from external Source

Automatic Test Report Generation that too non editable

3.2 Hardware Design Description

GCATE hardware design philosophy uses the Open System Architecture, which enables the generic modular approach for its realization in order to be adaptable for other platforms. The following factors have been considered in the hardware design of GCATE:

- Realization using Modular approach with Open System Architecture
- Generic: Configurable to other platforms
- Easy to upgrade
- Faster fault diagnosis
- Cost effectiveness
- Easy maintenance

The GCATE is a compact laptop based automatic test equipment which is designed with a USB based Controller Chassis along with Digital Input/output, Analog Output, Analog Input and relay boards are placed inside the enclosure of the GCATE. USB to RS 232/422 Converter, Power supplies, Interface PCBs are also placed inside the Enclosure.

There shall be Signal Monitoring Panel, which is used to monitor the Analog, Discrete, Frequency, ARINC-429, MIL 1553, ARINC-717 and Audio & RS232/RS422 for the self-test of GCATE. Any recorded sortie in the SSFDR is downloaded through a USB 2.0 cable via Laptop as shown below in the figure-2.

Customized Interface Electronics is the collection of Analog Signals Board, Discrete Signal Board, Frequency Signal's board, Fault Signal board & Power Supply board.

A laptop with USB and PCMCIA interface for ARINC429, MIL 1553 & ARINC-717 shall run the test equipment software. This laptop and power supply as shown in Figure no. 2 and connected to GCATE hardware with appropriate looms.

3.2.1 Test Rig Connectors & Looms

(i) Connectors

There shall be four connectors to mount on the back panel of the Test Rig. 2 socket type circular connectors with 100 pins, one socket type circular connector with 37 pin & one plug type Circular Connector with 32 pins.

(ii) External Looms

There shall be four looms of approx. 2 meters length to connect with SSCDR & Power Supply,

- Loom 1&2 will have one side 100 pin Socket type Circular Connector & Other side 100 Pin Plug type Circular Connector.
- Loom 3 will have one side 37 Pin Socket type Circular Connector & Other Side 37 Pin Plug type Circular Connector.
- Loom 4 will be used for power supply connection in which one side it will have clips to be connected with power & other side it will have 32 Pin Socket type Circular Connector.

The Break IN/OUT feature for electrical signals interfacing is provided in the GCATE. This capability allows the following:

- Signal Monitoring
- Signal isolation
- Signal injection from external source.

GCATE has been incorporated with safety grounding to safeguard personnel and equipment during operation, maintenance, repair and calibration. It is provided with a MCB (Miniature Circuit Breaker) for Powering On/OFF the rig. Power distribution to the LRUs is through the proper circuit breakers to prevent the damage to the LRUs, in case of any malfunctioning.

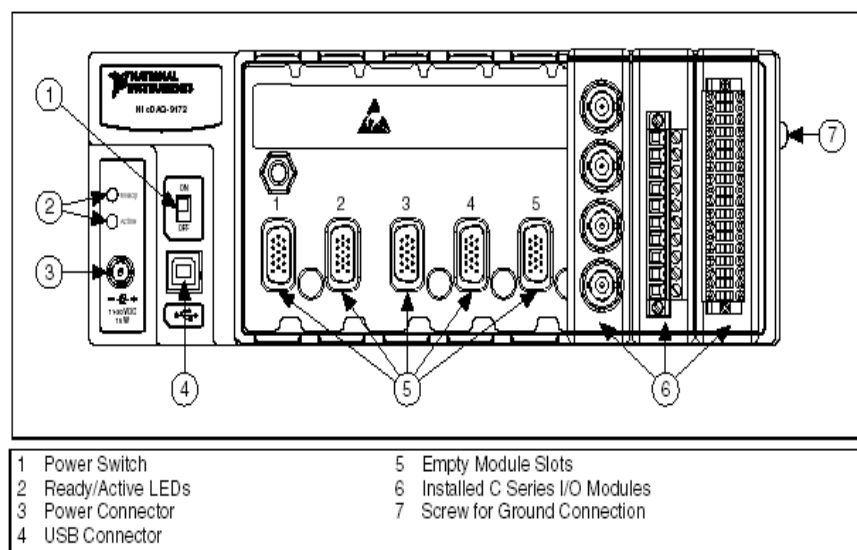


Figure 1: Back Plane of CDAQ

The below internal architecture define for a specific platform. The same away around may be configured for other platform also. One has chosen the compact modules (C series Modules) among the available in National Instruments for the specific purpose which can be fitted in the CDAQ chassis slot.

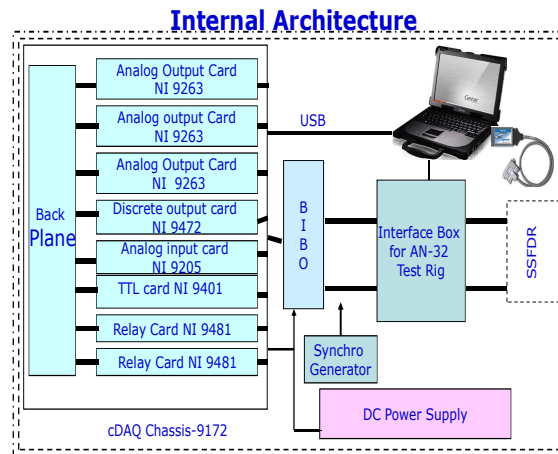


Figure 2: Block Diagram of GCATE for Specific Platform

The Figure 3 depicts that how one can use the generic feature of the entire system. The cDAQ Modules Interface provides the platform to connect the chassis as well as any type of module among the compact series of modules available in national instruments beside that one can replace the c DAQ chassis also by any other chassis which supports C series modules.

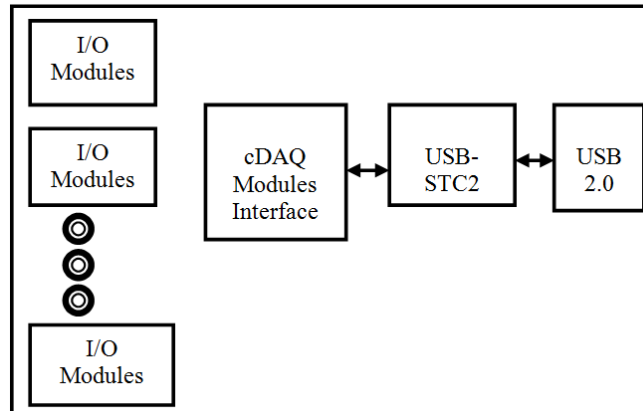


Figure 3: Cdaq-9172 Block Diagram

3.3 Parameter Simulation & Hardware Detail

For Standalone and Integration testing, lot of parameter/ sensor simulation is provided to carry out checks on all interfaces.

Arinc429, MIL 1553, ARINC-717 RS422/485/232, DIO, Analog signals is simulated using PCI based add-on cards installed in Rugged Laptop.

The Following Hardware shall be part of the GCATE. The present standard module may get changed due to non-availability of these modules

(i) Analog Output Module

The 16 Channels high performance analog outputs which provide accurate signal generation with 16 bits output resolution is required.

(ii) Analog Input Module

8-channels analog input module with the range of 0 to +32V with 12 bits resolution are required.

(iii) Relay Module

There is a requirement to generate 24 discrete parameters channel solid state relay with a Relay open time 0.5 ms & Relay close time 9.0 ms or better is required.

(iv) 5v/T tl Bidirectional Digital I/O Module

There is a requirement to generate 32 TTL signals so at least required of 7 μ s bidirectional digital input/output module with 5V/TTL can be achieved.

(v) USB to RS 422 Converter

This standard module to convert the USB input to RS 422 output or vice versa. RS 422 is used for telemetry. It should have specification defined below or better.

(vi) USB To RS 232 Converter

This standard module to convert the USB input to RS232 output or vice versa. RS232 is used for SSCDR programming and debugging. It should have specification defined below or better.

- Specification RS232: Transfer Rate 230.4kb/s & FIFO size 128B
- Specification USB: Data Rate 480kb/s & Ver.2.0

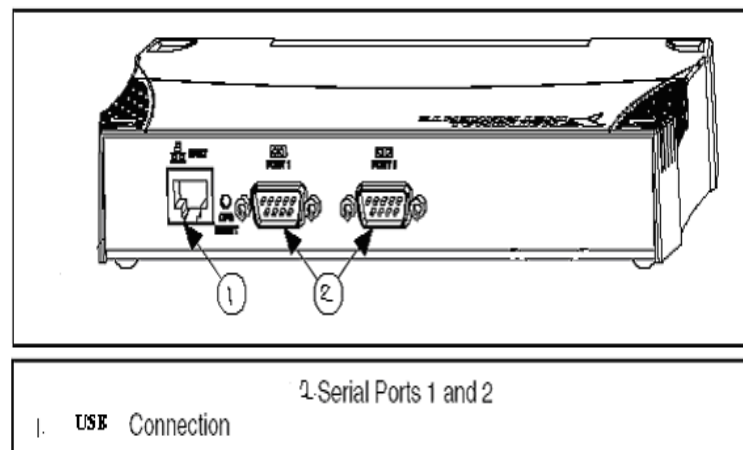


Figure 4: Back Panel of USB to RS232/485 Module

(vii) Power Supply

One standard power supply is used to generate the different DC power supplies $\pm 15V$, $+5V$ & $+28V$ at 2A current for the operation of test equipment.

(viii) Rugged Laptop

The GCATE shall be developed using a laptop with minimum following configuration:-

Processor: Core Duo

Frequency: 1.4 GHZ

RAM: 512 MB

USB ports: 2

Hard disk: 80GB

Ethernet Port: 10/100/1000 base TX (1no)



Figure 5: Rugged Laptop

Table 1: Parameter Generation Detail

S/N	Parameter	Range/Type	No. of Parameter	Total
1	Analog Parameter	0-10V analog voltage	10	16
		0-5V anaog voltage	10	
		0-28V	10	
2	Dicrete Parameter	28V DC/OC	4	24
		28V/ DC/OC	12	
		0V/OC	2	
		0V/OC(Spare)	6	
3	Frequency Parameter	7-5000Hz	03	04
		Spare	01	
4	Audio Parameter	300Hz to 3500Hz	03	02
		Spare	01	
5	TTL Parameter	0 to 5V DC	25	03
6	ARINC 429 Data	0-32 Bit	Channel 12 Parameter 95	16
		0-32 Bit(Spare0	04	
7	MIL 1553	0-32 Bit	10	10



Figure 6: Arinc-429mil 1553, & Arinc-717 Card

3.4 Software Description

Software is becoming increasingly more important in long term sustainment as it continues to define more of the test system functionality. Key software architecture for mitigating the impact of obsolescence is the implementation of modular architecture. The software for GCATE has been developed around Lab View, C & VC++ software, Lab View is a Graphical User Interface tool of National Instruments which provides easy & modular programming. Lab View is Virtual Instrumentation i.e vi based programming tool.

Some of the key design Software features are listed below:

- **Modular Architecture**

The software contains various modules with similar functionality in separate library VI and executables (*.exe) files.

- **Database Driven Architecture**

Simulation software is independent of simulation quantities and types, object names, data definitions, constants and data range limits, so GCATE validation need not be repeated when system parameters change.

- **User Help**

Help file contains information about Rig usage, all command line interface functions etc.

- **Diagnostic**

Performs Self-Test for hardware modules as soon as software started

- **Multiple user login**

Multiple user login is provided and user login details are stored in the test report for reference.

- **Reports**

Test report in non-editable PDF format. Complete test results with a description and PASS/FAIL results are stored in report for fault diagnosis.

A few snapshots of the Application software are shown in Figures below.

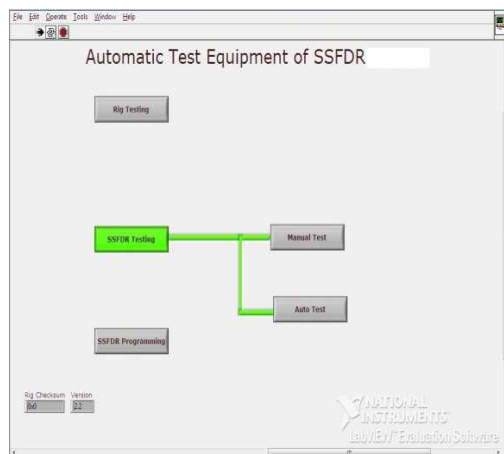


Figure 7

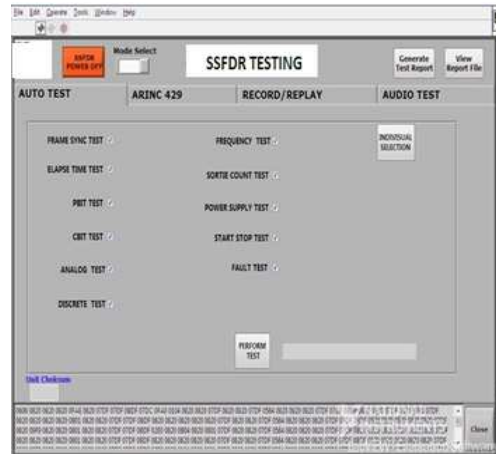


Figure 8

3.5 Innovation and Creativity

- Modular design using USB based Compact technology.
- Automatic testing methodology and automatic test report generation
- Simulation feature
- Software reusability
- Reconfigurable design concept
- Easy fault isolation and self-test

3.6 Certification Challenges

Aircraft/Avionics System development requires high quality equipment conforming to the environmental conditions.

In the context of general standards available for the development and certification of ground test equipments, there can be a possibility to interpret the standards in different ways.

Hence, during the initial product definition or preliminary design reviews, along with the scope of the product it is very imperative to clearly define qualification aspects, route to certification, in agreement with all the concerned parties and certification authorities.

4. CONCLUSIONS

Innovative System design of GCATE developed in-house to cater for the needs of the Line Replaceable Unit, testing at various phases of aircraft/avionics system life cycle, has been discussed. A novel approach has been illustrated for the realization of the GCATE by the use of open system architecture, resulting in the cost effectiveness and tremendous growth potential. Further, Open system modular architecture based solution approach is realized in both Hardware and Software development which extends the applicability of these Test equipment's across various platform, not only limited to one aircraft. The notable learning during the in-house development of the project which can be useful for any similar future projects, have been explained.

REFERENCES

1. DDPMAS Vol. II Section “Design and development of Ground Equipment,”
2. JSS6625-01:2002, General Requirements for Electrical & Electronics Test Equipment (JSS6625-01:2002, Revision: 01).
3. JSS 5555: 2000, Joint Service Specification on Environment Test methods for Electronics & Electrical Test Equipment (JSS 5555:2000, Revision No.2).
4. Dharani, K., Subalakshmi, S., & Balamurugan, D. (2014). Automatic agriculture irrigation with periodic camera trapped pictures and land monitoring using wireless sensor network. *International Journal of Research in Engineering & Technology (IMPACT: IJRET)*, 2(5), 255-260.
5. For ARINC 429 www.digilander.libero.it/LeoDaga/Corsi/AD/Documenti/ARINCTutorial.pdf
6. www.ni.com : The website of National Instruments Products
7. Datasheet of RS 232 & RS422 from www.digital.ni.com › Support
8. For Power Supply www.aplab.com/.../power-supplies/variable-output-linear-power-supplies.
9. Data Sheet of LM324 www.alldatasheet.com/datasheet-pdf/pdf/22753/.../LM324.html
10. Datasheet of Amphenol Connectors www.amphenol-in.com/
11. For RS 422 www.ftdichip.com/Products/Cables/USBRS422.htm

